

How's the Water?

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PROPOSAL

I propose to study how people's use of fresh water has affected water quality. With ever expanding populations I would look at how some of mans manipulation of fresh water supplies is affecting the natural hydrologic cycle and water quality.

We use water for drinking, sanitation, irrigation and industry. How are these uses affecting the hydrologic cycle and water quality?

I live in a dry area near the coast. Due to irrigation and urbanization the aquifer in this area is being pumped out at an alarming rate. This does not seem sustainable. I would like to look at the possible consequences of this pumping.

Big dams have been built all my life. How has diverting and storing all this water affected the natural hydrologic system and what are some of the consequences of these diversions.

ANNOTATED BIBLIOGRAPHIES

Specter, Michael. "The Last Drop." *New Yorker Vol. LXXXII, No. 34*. Oct. 23 2006: 60-71. *SIRS Researcher*. Web. 06 July 2010.

This article discusses how the current practices of water use are not sustainable. Only 3% of the water on earth is available to drink and most of that is tied up in polar ice caps and glaciers.

Aquifers are a main source of water and they are being depleted at an alarming rate. Drilling an aquifer too deep can cause salt water and arsenic to seep in and forever ruin the source.

Politics play a major role in water collection, storage and availability, the poor are under represented and don't get their share. On the coasts of India and China collection and storage of rainwater during the monsoon season is an important future development if we are to provide water to people during the dry season.

Rogers, Peter. "Facing the Freshwater Crisis." *Scientific American Vol. 300, No. 1*. Aug. 2008: 46-53. *SIRS Researcher*. Web. 06 July 2010

This article talks about how 1 in 6 people worldwide don't have access to safe drinking water and how by 2030 more than half the countries of the world will be stressed for water or have outright shortages. The author discusses ways that we can begin conserving now. Increasing water prices will get peoples attention that there is a problem with supplies and encourage conservation. Water banks are discussed, where aquifers are refilled with run-off from rain water. Decoupling drinking water from sanitation is another idea presented. The author also discusses the idea of desalination through more energy efficient plants employing membrane reverse osmosis which now costs 30% less than it used to, making it a feasible option.

Unknown. "Drought--The Silent Crisis Part 1: Definitions and Causes." *Know Your Environment*. 22 Mar 2005: n.p. *SIRS Researcher*. Web. 06 July 2010.

This author discusses water supply as it is affected by drought. Types of drought are defined; the National Drought Mitigation Center (NDMC) defines types of drought, like 'ground water drought' and 'surface water drought'. The hydrologic cycle is discussed and the role of supply and demand is associated with conditions referred to as drought. Like other environmental issues, dealing with the problem of drought means using a combination of effective governing, understanding of the science and engaging an informed public.

Unknown. "A Special Report on Water: Enough Is Not Enough." Economist (London, England) Vol. 395, No. 8683. 22 May 2010: 6+. SIRS Researcher. Web. 07 July 2010.

Water scarcity is not the only problem with water supply. When dams are built accumulated water becomes stagnant. Mosquito's breeding ground is stagnant water and they carry diseases like malaria and dengue fever which they pass on to humans. The biggest single cause of childhood death is diarrhea or diseases related to it. Clean water for drinking and sanitation are essential for good health. Many people in LDC don't have access to sanitation forcing them to defecate in public. There is now an international effort underway to improve sanitation and make sure the drinking water is safe. Cheaper water filters that don't use energy are being made available beginning in Mexico

Schneider, Howard. "World Bank's Water Aid Misses Neediest Nations." *Washington Post (Washington, DC)*. 23 Mar 2010: A.14. *SIRS Researcher*. Web. 07 July 2010.

The World Bank has invested nearly a third of its total lending, more than 54 billion dollars toward water projects between 1997 and 2007. However there is little correlation between bank lending and water stress. The most water deprived countries like Ethiopia, Haiti and Niger, for improvements in water supply, received approximately \$20 per capita while the water rich nation of Guyana received more than \$140 per capita. The World Bank claims that there has been a shift in their priorities and that funding for water projects in water poor nations has tripled since 2003 to 60% of available loan money.

Cowan, Kenneth. "Harvesting Rain." *Ecologist (London, England) Vol. 38, No. 5*. June 2008: 40-43. *SIRS Researcher*. Web. 12 July 2010.

This article discusses the ancient hydrologic systems of the Middle East and how instead of being looked at as curiosities we could use the methodologies to help alleviate the current water shortages being experienced worldwide. Collecting rainwater from your roof to irrigate the garden, in what is referred to as a water butt, is discussed as a way to save water on an individual basis. This could also protect a community against seasonal flooding by catching rainwater before it becomes run-off. Thirty-one countries are facing water scarcity and a billion don't have clean water to drink. Water consumption doubles every 20 years and a global crisis is coming because climate change is putting more pressure on supply. Pollution, depletion, diversion and exploitation are all problems we need to deal with. Clean water is quickly becoming a commodity only the rich can afford.

Scully, Malcolm G. "The Politics of Running Out of Water." *The Chronicles of Higher Education. B18*. Nov. 17 2000. 13 July 2010.

This article predicts that in the coming century there will be wars over water. The article suggests that we are facing a water crisis that threatens social, economic and environmental stability. Instead of a world shaped by political boundaries it is seen as a collection of water-sheds, lakes, rivers and aquifers that maintain the world's biota. This is a time when humans have expanded their use of water to meet the needs of industry, agriculture and expanding populations. There is now a scarcity that threatens food supply, human health and global ecosystems. This article also states that an aquifer on the United States-Mexico border will run dry in 25 years. Scary when one considers that this article is 10 years old. Alternatives to large dams and ways to collect water, like from fog are touched on. Also stated is the fact that over the course of human history most irrigation-based civilizations have failed.

McKinnon, Shaun. "A Looming Choice." *Arizona Republic (Phoenix, AZ)*. 25 Oct. 2009: A.1. *SIRS Researcher*. Web. 14 July 2010.

This article discusses the Colorado River and the struggle to sort out what the best uses for the water are. More than a billion gallons a day are used to irrigate water-needy crops like cotton, lettuce and melons. Crops yield about 1% of Arizona's annual income but soak up 70% of the water supply. Avoiding "my use is better than yours" thinking is important but there needs to be a better way than just whoever has the most money gets the most water. According to western water law, who ever stakes their claim first gets the rights to the water, which means if the river starts to run dry the farmers get their share first. Critics are complaining that farmers grow too many water-needy crops and pay too little for the water they use. Urban areas view agricultural water as a back-

up supply in case of shortages but farmers can refuse to give up their supply, even temporarily.

Shenkar, Laura. "Blue Technology Can Quench America's Thirst." *USA Today (Farmingdale)* (Vol. 138, No. 2772). Sept. 2009: 62. *SIRS Researcher*. Web. 15 July 2010.

This article discusses the fact that the United States faces a huge challenge over the next decade ensuring that we have enough water, with 36 states anticipating shortages over the next five years in an economic climate that doesn't recognize water as a priority. Education seems to be a huge factor. This article states that New Englanders use less than 20 gallons of water per day per person while south westerners use about 200 gallons per person per day. Runoff pollution is a big problem with the rapid development of communities. Bringing back rainwater harvesting is a good idea but the issue of water-borne diseases must be addressed. Advanced water technology, becoming known as 'blue technology' is an important and promising industry which could provide solutions to the wide spread water dilemma. Four main technological challenges are addressed in decentralizing water infrastructure; real time monitoring at the point of use, on-site waste water reclamation, advanced membranes to enable cost effective means for saving energy and water, and more efficient cooling systems. Innovative technology is needed to shore up deteriorating centralized infrastructure and provide new and sustainable decentralized approaches needed to protect our waterways. These new 'blue technologies' need support through new laws and funding.

Molden, David, et. al. "Water Scarcity: The Food Factor." *Issues in Science and Technology* Vol. 23, No. 4. Summer 2007: 39-48. *SIRS Researcher*. Web. 19 July 2010.

This article has loads of information in it. Population expansion is discussed in that the world must feed an additional 2 to 3 billion people over the next 50 years and that 70% of the world's 850 million undernourished live in rural areas where accessing enough water is a daily struggle. The amount of water that plants need to grow is discussed stating that the amount of water people need for drinking is only about 0.01% of the water required to produce food. People's diet choices are clearly becoming important since crop yield is roughly proportional to transpiration. It takes between 500 and 4000 liters of evapotranspiration to produce a kilogram of grain. When this grain is fed to animals it takes between 1,500 to 15,000 liters of water to produce a kilogram of meat. The article breaks it down to say that about one liter of water is required per calorie of food supply. Meat produced on rangeland requires much less water than industrial feed-based processes. Improved economic trends lead to higher rates of meat consumption. With growing incomes and changes in diets worldwide, food and feed demand could double by the year 2050. Water consumed by agriculture is likely to double as well. Globally agriculture withdraws 70% of the water drawn from aquifers. Intensive irrigation has led to closed drainage basins where all the water is allocated to specific uses. Irrigation is the single most important reason for closed river basins and contributes to physical water scarcity. In the future, fisheries will compete with irrigated crops for water and it is the poorest of the poor, who depend on the highly nutritious fish products, who will suffer the greatest consequences. We need to improve crop yields

with new technologies or else expand agricultural land by more than 50% by the year 2050. Many view pricing as the way to improve water productivity by reducing water waste in irrigation. We need a more integrated approach for managing our water; agriculture/aquaculture systems and better integration of livestock management into irrigated and rain-fed systems are places we can start. We need to make sure that the gains made toward clean water availability reach the rural poor and are not taken by wealthier or more powerful users. The article declares the ultimate cause of our water problems is inadequate institutions and that reform is needed.

OUTLINE

A water crisis is on the horizon. There have been serious consequences from human alterations to the natural hydrologic cycle.

1. Pollution

- a. Agriculture***

- b. Sanitation***

- c. Industry***

2. Depletion

- a. Aquifers**

- b. Coastal inundation**

- c. New technologies**

3. ***River Modification***

- a. Large dams**

b. Fishing

c. Disease factor (malaria)

d. Environmental impact

Summary

Conclusion

Why is this important?

INTRODUCTION

A global water crisis is on the horizon. When examining human inputs to the natural hydrologic cycle, a change in water quality has become the real consequence.

Studying the water resources of the world it became clear that trouble is on the horizon. Pressure is being put on fresh water supplies from many different sources. The population growth humans are experiencing demands expanded agricultural practices. The green revolution is meeting that need. However, with expanded agriculture, pollution is a big problem. Pesticides are introduced into our water and fertilizer run-off adds to eutrophication. Lack of proper sewage facilities and industry are other contributors to polluted waterways.

Depletion of ground water aquifers is another large problem. Aquifers are used to provide irrigation, sanitation and drinking water but inundation of coastal aquifers from sea level rise is a very real problem. New blue technologies are being developed to aid us in knowing the condition of our aquifers.

Modification of rivers for storage and flood prevention has led to the closing of some major drainage basins worldwide that threatens the health of the world's hydrologic cycle. Our exploitation of water resources has put pressure on us to come up with new blue technologies in order to provide clean water.

The hydrologic cycle, according to The New Encyclopedia of Science, is

The natural circulatory system in which water is cycled through the environment. Essentially it involves precipitation (rain or snow) falling on the land, from which water runs off into streams and rivers that eventually reach the oceans. Ocean water evaporates from the surface, and in the atmosphere water condenses to form droplets that fall as rain. Some water is "consumed" by plants and animals which, through transpiration or respiration, release it directly into the atmosphere as water vapor. (Morgan and Allaby) (See figure 1).

Although rain appears to increase the amount of water available to us, this is just an illusion. The amount of water is constant, just recycled through the hydrologic system. About 70% of the earth is covered by water however the majority of it is in the oceans. According to the National Aeronautics and Space Administration,

About 96.5% is in the global oceans. Approximately 1.7% is stored in the polar ice caps, glaciers, and permanent snow, and another 1.7% is stored in groundwater, lakes rivers streams and soils....groundwater constitutes approximately 30% of fresh water, whereas ice...constitute approximately 70% of fresh water. (Graham, et. al.)

(See figure 2).

The green revolution refers to advances in worldwide agricultural production. According to The World and I, "...that effort has led to impressive gains in global food

production: over the last two decades, it has more than doubled the yields of rice and wheat and reduced the costs of their production by nearly a third!" (Combs, et. al.)

International research centers coordinated their efforts and came up with new technologies to improve food production. Genetic engineering has led to new high yield varieties of cereals. These new high yield varieties

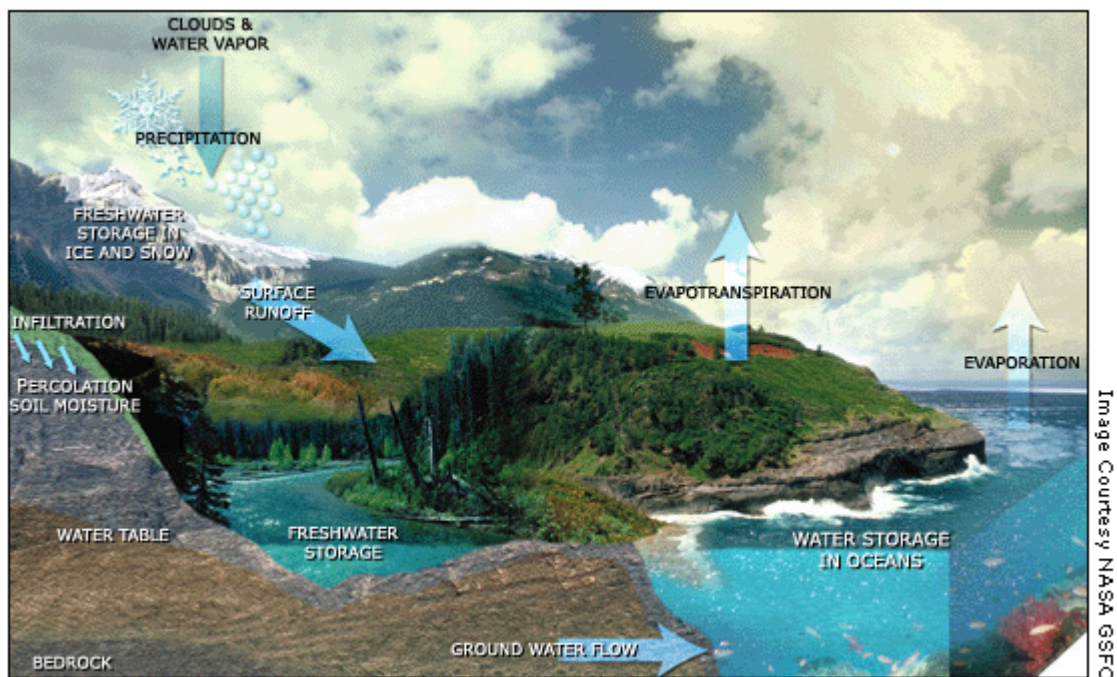


Fig. 1

Ward, Alan. "Weighing Earth's Water from Space." *Earth Observatory (National Aeronautics and Space Administration)*. Dec. 23 2003: n.p. *SIRS Researcher*. Web. 13 Sep 2010.

The image shows the many processes of the Earth's hydrologic cycle that contribute to total changes in water storage. Because a large portion of the Earth's usable fresh water is located in underground aquifers, scientists are interested in determining how groundwater supplies are changing with time.

One estimate of global water distribution:

	Volume (1000 km³)	Percent of Total Water	Percent of Fresh Water
Oceans, Seas, & Bays	1,338,000	96.5	-
Ice caps, Glaciers, & Permanent Snow	24,064	1.74	68.7
Groundwater	23,400	1.7	-
Fresh	(10,530)	(0.76)	30.1
Saline	(12,870)	(0.94)	-
Soil Moisture	16.5	0.001	0.05
Ground Ice & Permafrost	300	0.022	0.86
Lakes	176.4	0.013	-
Fresh	(91.0)	(0.007)	.26
Saline	(85.4)	(0.006)	-
Atmosphere	12.9	0.001	0.04
Swamp Water	11.47	0.0008	0.03
Rivers	2.12	0.0002	0.006
Biological Water	1.12	0.0001	0.003
Total	1,385,984	100.0	100.0

Source: Gleick, P. H., 1996: Water resources. In *Encyclopedia of Climate and Weather*, ed. by S. H. Schneider, Oxford University Press, New York, vol. 2, pp.817-823.

Fig. 2

depend upon substantial inputs in the form of fertilizers and other agricultural chemicals. These inputs lead to pollution and eutrophication. A new even greener revolution is called for.

Blue technology is just a catch phrase referring to new water technology. This is an important and promising industry which according to USA Today, "...should enable us to borrow knowledge from consumer products, industrial design, and advanced natural sciences to provide leading-edge solutions to the wide spread water dilemma." (Shenkar) Some of the new technologies being developed include more advanced membranes to clean water and save energy, and ways to track aquifer supply and quality. Deteriorating centralized infrastructure is in need of revamping and new innovative products and ideas are needed. These new blue technologies need government support through new laws and funding so acquiring public backing for this idea is imperative. USA Today claims that, "...every dollar invested in public water and sewer infrastructure and services yields approximately \$8.97 for the national economy." (Shenkar) Supporting this idea could benefit us in more ways than just ensuring fresh water supplies, it can grow the economy.

1 Pollution

One of the major problems with fresh water supply is pollution. Water pollution occurs in different ways including agricultural runoff, lack of infrastructure for sanitation, and industrial pollution.

Water pollution may be defined, according to the Journal of Water Resources and Protection (JWARP), as... “any impairment of its native characteristics by addition of anthropogenic contaminants to the extent that it either cannot serve to humans for drinking purposes and/or support the biotic communities such as fish.” (Agrawal, Ravi, Bechan)

The water pollution that is a consequence of agriculture is due to runoff, drift and leeching (see figure 3) of pesticides and fertilizer. The runoff can be due to the natural effects of precipitation or human induced effects such as irrigation. Water always runs downhill so pollution is worse at the lowest point in any area.

The chemicals used for agriculture include pesticides and fertilizers. According to the Journal of Water Resource and Protection, the Environmental Protection Agency (EPA) published a report in 1990 stating that...

>50% of the water pollution of streams and rivers occur due to leaching and mixing of chemicals from agricultural practices. [JWARP says that,] “The major part of the pesticides applied in any area for a specific reason (about 99%) remain unused and it gets mixed with the air, soil, water and plants which by several means causes harmful effects on the people, pets and the environment. [Pesticides are generally species specific and not intended to harm humans, however JWARP states that] The constant exposure of pesticides to non-target species may lead to induced toxicity once it crosses the threshold limit in the system. It is known that the major portion of the pesticide applied reaches into healthy environmental components such as aquatic reserves (ponds, lakes, rivers and oceans), where they gradually get accumulated into other organisms...The pesticides have been shown to display their effects by causing xenotoxicity, alterations in the bodies immunity, reproductive system, and other physiological processes of different organisms thereby generating several diseases including cancer.(Agrawal, Ravi, Bechan)

Pesticides are chemicals used worldwide to increase crop yields, control pests and treat fungus. At the same time they control vector-borne disease that would otherwise run rampant. Citing a report known as the Western Airborne Contaminants Assessment Project the Seattle Post-Intelligencer states that,

thresholds at the eight parks that researchers focused on [and that while] much of the contamination is thought to have come from overseas---traveling global air currents from Europe and Asia...researchers were surprised to find substantial contamination from the local use of legal pesticides, [and while DDT and other pesticides with a long life in the environment were banned and were replaced by pesticides with a shorter life time in the environment,] ...in places like the Central Valley of California, we are applying many, many tons of these every year.
(Study: High Toxin Levels in Nat'l Parks)

(See figures 4 and 5).

Pesticides...are raining down on national parks across the West and Alaska, turning up in dangerously high levels in lakes, plants and fish...Contaminants that accumulated in fish exceeded human consumption.

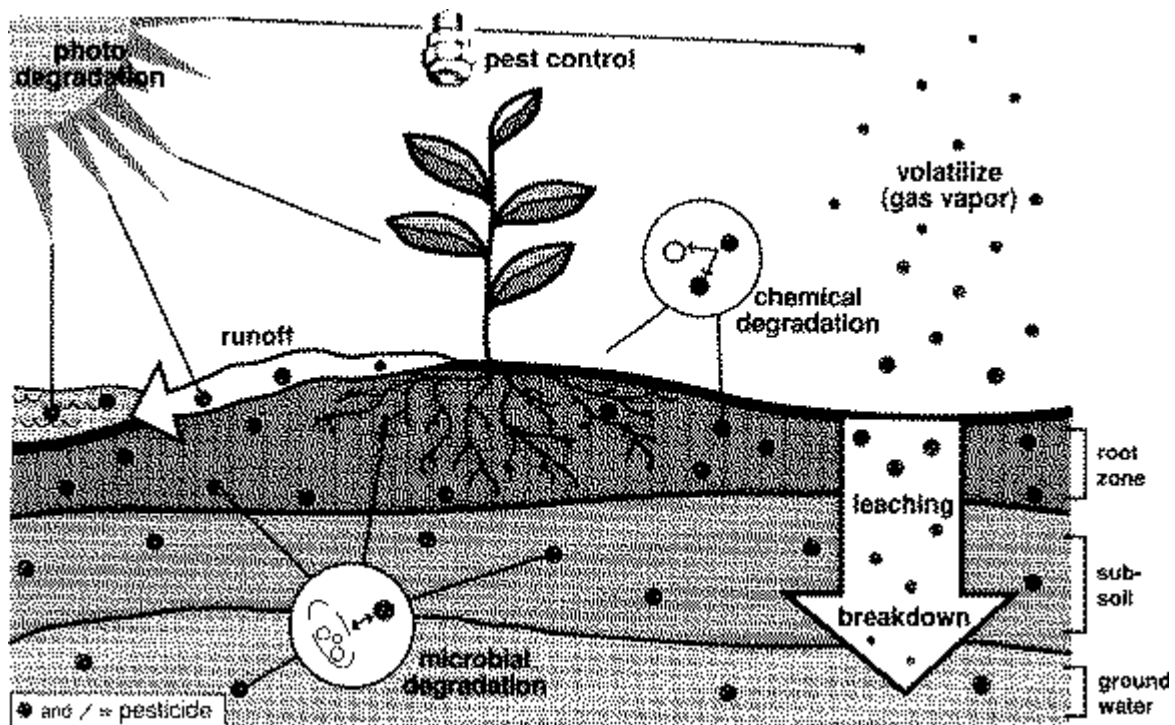


Fig.3

Cooperative Extension work in Agriculture and Home Economics, state of Indiana, Purdue University, and U.S. Department of Agriculture cooperating; H.A. Wadsworth, Director, West Lafayette, IN.

Fertilizer is another pollutant introduced into our water supply by agriculture. It is a part of the green revolution intended to boost food production and while it is beneficial for what its intended, the ramification is eutrophication. Eutrophication is defined by the Columbia Encyclopedia as,

...aging of a lake by biological enrichment of its water. In a young lake the water is cold and clear, supporting little life. With time, streams draining into the lake introduce nutrients such as nitrogen and phosphorus, which encourage the growth of aquatic organisms. As the lake's fertility increases, plant and animal life burgeons, and organic remains begin to be deposited on the lake bottom. Over the centuries, as silt and organic debris pile up, the lake grows shallower and warmer, with warm-water organisms supplanting those that thrive in a cold environment. Marsh plants take root in the shallows and begin to fill in the original lake basin. Eventually the lake gives way to bog, finally disappearing into land. Depending on climate, size of the lake, and other factors, the natural aging of a lake may take thousands of years. However, pollutants from man's activities can radically accelerate the aging process. During the past century, lakes in many parts of the earth have been severely eutrophied by sewage, and agricultural, and industrial wastes. The prime contaminates are nitrates and phosphates, which act as plant nutrients. They overstimulate the growth of algae, causing unsightly scum and unpleasant odors, and robbing the water of dissolved oxygen vital to other aquatic life. At the same time, other pollutants flowing into the lake may poison whole populations of fish, whose decomposing remains further deplete the

water's dissolved oxygen content. In such fashion, a lake can literally choke to death (Eutrophication).

(See figures 6 and 7).

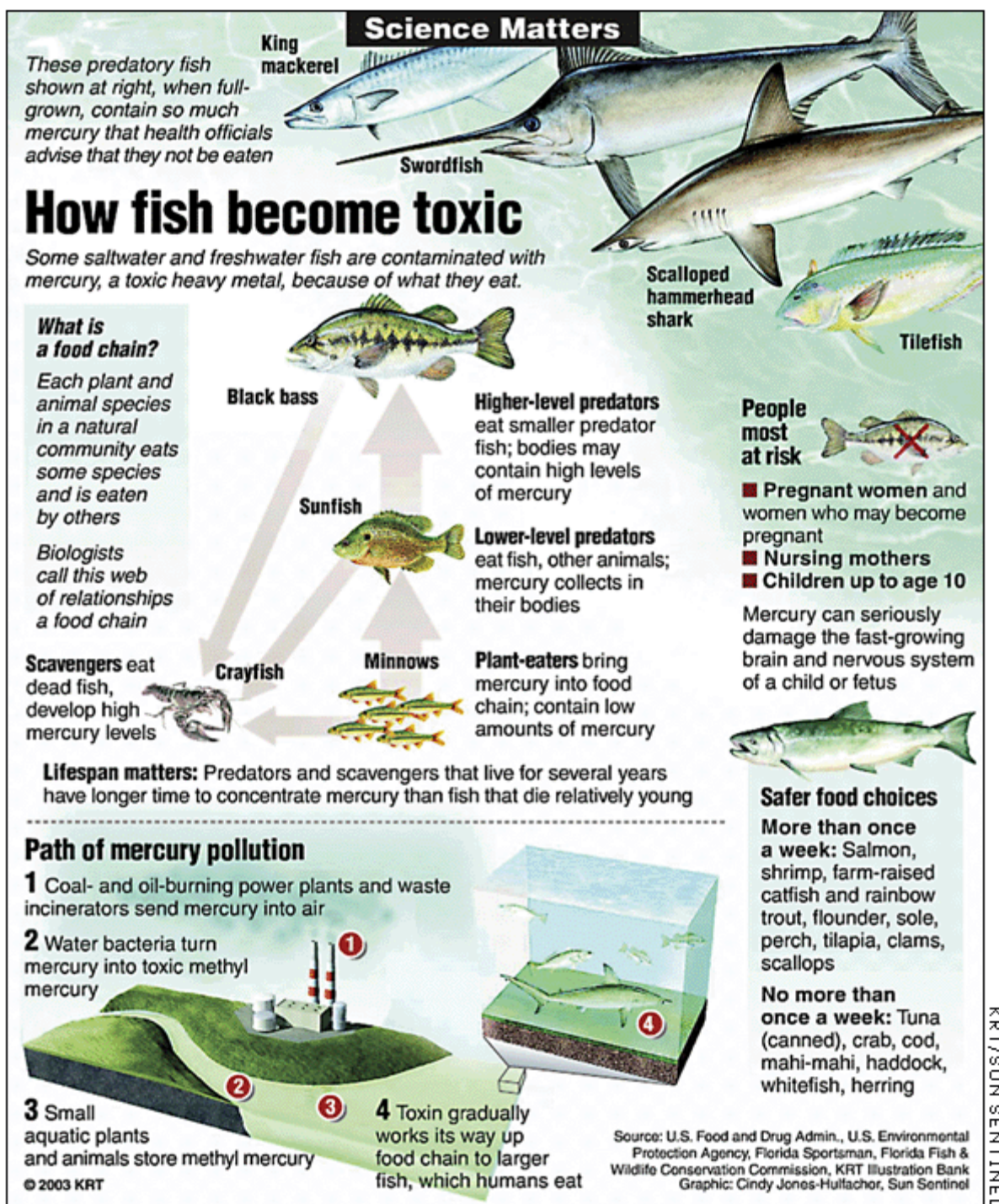
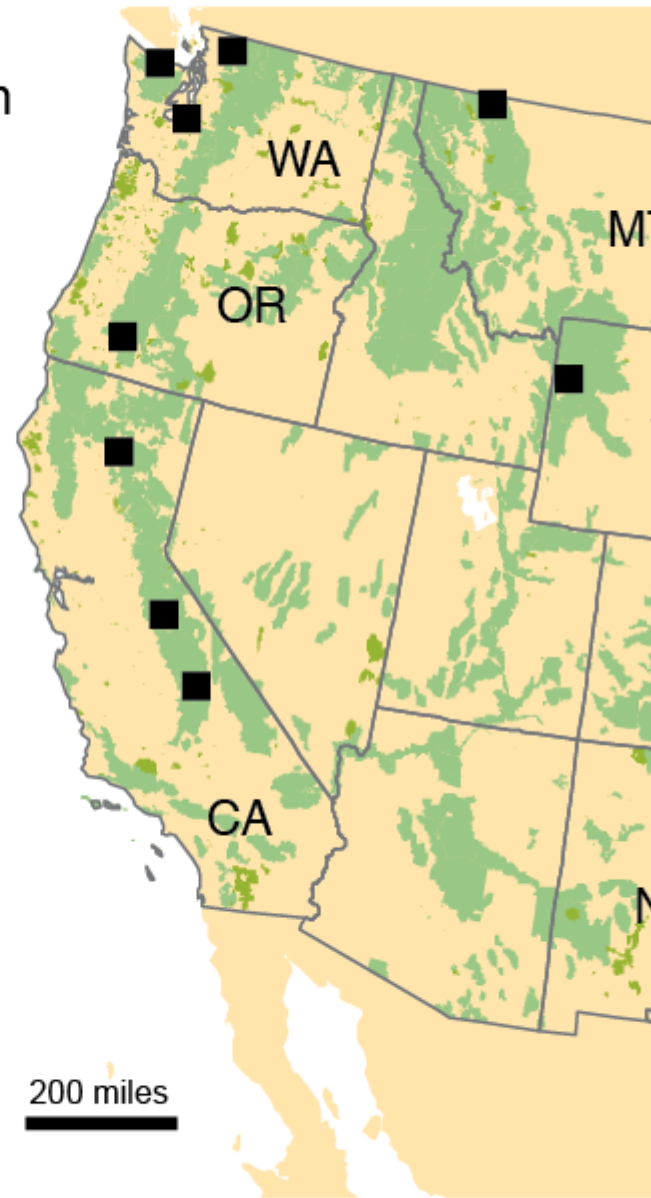


Fig. 4

Pesticides prevalent in western

A federal study found evidence of 70 contaminants in 20 national parks and monuments – from Denali in Alaska and Glacier in Montana, down to Big Bend in Texas and Sequoia in California.

■ Park tested for contamination



SOURCE: National Park Service

Fig. 5

Unknown. "Study: High Toxin Levels in Nat'l Parks." *Seattle Post-Intelligencer* (Seattle, WA). Feb. 27 2008: n.p. *SIRS Researcher*. Web. 13 Sep 2010.

Lack of sanitation in urban areas is another major problem that we have with our fresh water supplies. When sewage is in our water supply it causes disease. According to the U.N. Department of Public Information,

There are currently 2.6 billion people or 42% of the world's population, without improved sanitation. [It goes on to say that,] There is compelling evidence that sanitation brings the greatest public health returns of any policy intervention, but...is rarely included in the development agenda...with the world's poorest communities being disproportionately excluded from water service...in Ethiopia, the official coverage is just 22%... Water, sanitation and hygiene education are essential in the fight against...diseases...because they put barriers in the faecal-oral transmission routes...Every day diarrhoeal (sic) diseases cause 4,900 deaths of the under-fives and they are the second biggest driver of infant mortality. Of these deaths 90 percent are attributed to poor hygiene, sanitation and unsafe drinking water. (Frost)

One version of the problems in the lack of adequate facilities occurs on the Bassac River in Cambodia where, according to The Saint Paul Pioneer Press,

The river served simultaneously as toilet, wash basin, playground, transportation and food source.... While children defecated over the sides of boats, other children could be seen swimming 20 yards downstream. On the river banks, women bathed babies and washed dishes, then wades [sic] to midstream to collect pots of water. (Moore)

Sources of Cultural Eutrophication

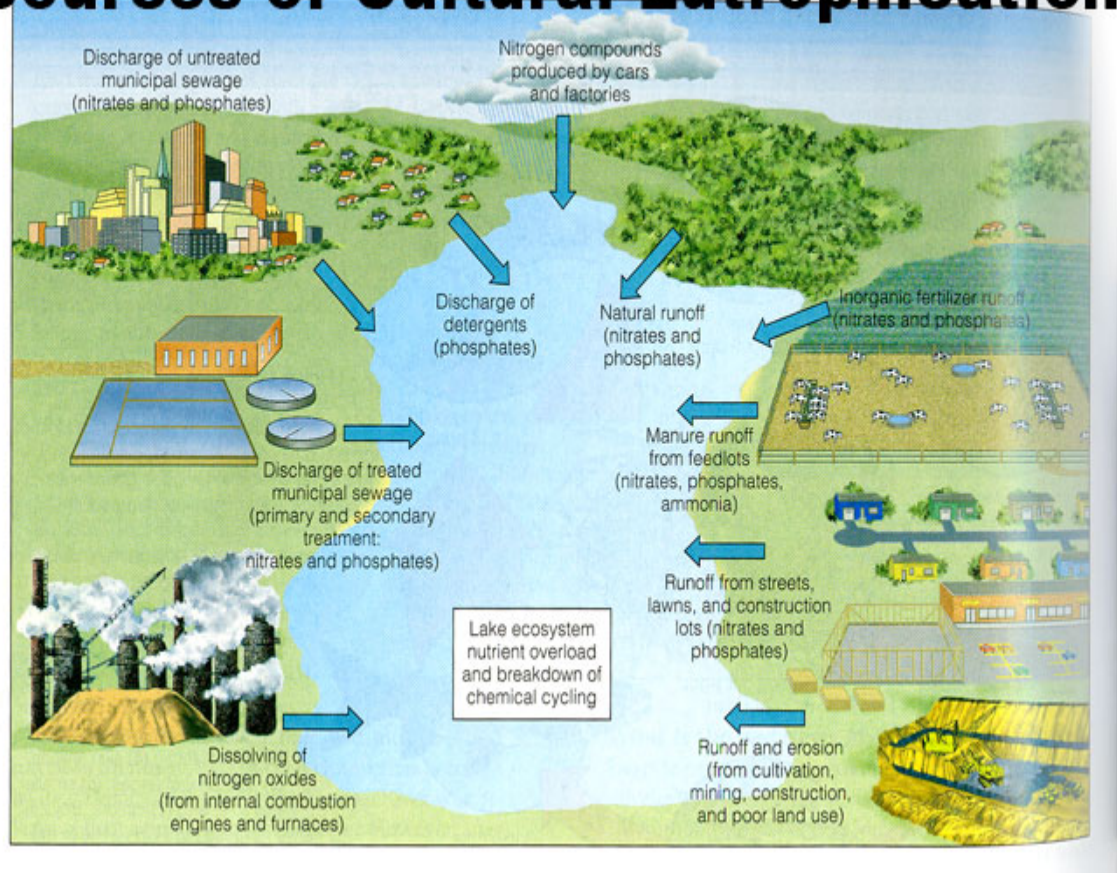


Fig. 6

Thinkquest Team "Fish," March 2005



Eutrophic lake with blanket weed covering the surface

Fig. 7

The content in this site was developed by Dale Fort Field Centre

Crumbling infrastructure is another way that sewage is introduced into our drinking water. Even in the United States, which is considered as one of the most developed nations in the world, the infrastructure is crumbling. According to USA Today,

...the pipes that deliver and remove water from our homes and businesses are collapsing as a result of decades of neglect. The U.S.'s drinking water piping network extends more than 700,000 miles and much of the infrastructure is more than 100 years old. With the over 1,200,000,000 miles of sewage piping in the U.S., storm water and sewage collection systems fail daily, stopping business and creating significant health hazards. (Shenkar)

Similar issues are being experienced elsewhere. According to The Saint Paul Pioneer Press,

In cities such as New Delhi and Phnom Penh, water and sewer lines are laid next to each other. Now, as a result of age and poor maintenance, many of the conduits are crumbling, and raw sewage bleeds into the water lines, which only intermittently flow at full pressure. (Moore)

Industry introduces huge amounts of pollutants into our water ways. For example, paper making is very polluting. OnEarth magazine says that,

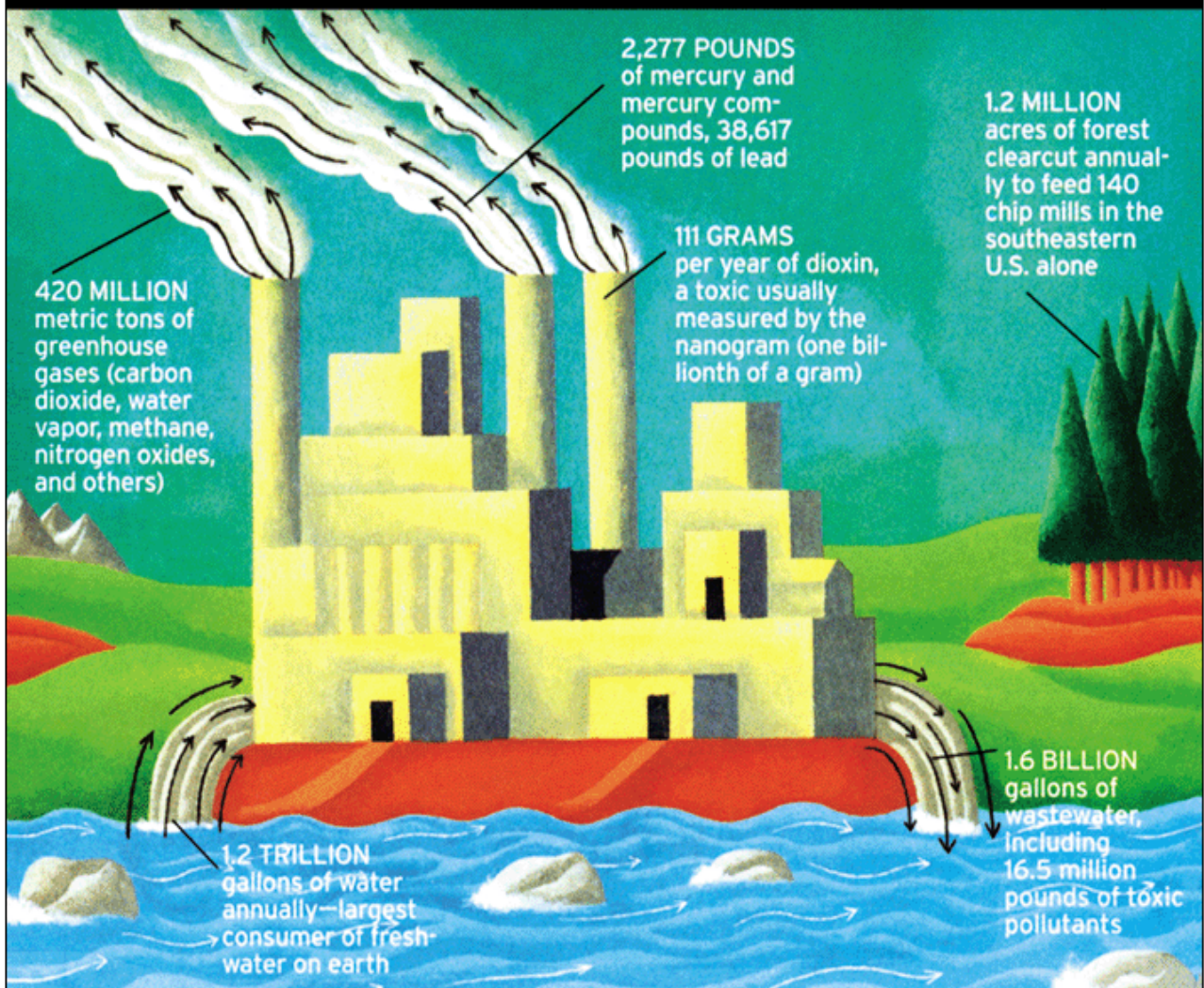
Converting the timber...into pulp and paper requires tons of chemicals per day. [And]...The residue after the pulp is broken down includes some of the most hazardous and toxic substances in existence, such as chlorinated dibenzo P dioxins, mercury, and lead. Most of the mill's contaminated effluent is discharged into several huge sludge ponds...There it is broken down chemically and eventually discharged into the river. [This article goes on to say that] In the early nineties the Calhoun Mill had a "color issue": Its effluent changed the color of the Hiwassee (river). But the state worked with them on it, by raising the threshold of permissible visible color change so the mill could meet its water-quality standard. (Shoumatoff) (See figure 8 and 9).

Ford Motor Company is a staple of the American industrial economy. You would think that they would take care not to poison the residents around where their plants are located but in a country where capitalism is king making money seems to be at the top of the agenda.

In 1955 Ford opened a new assembly plant in Mahwah, New Jersey. By 1965 they began to dump their waste around the nearby town of Ringwood. Two years before they started this dumping they were warned by officials that if they were to dump waste on the mountain that there could be serious consequences for the watershed. They dumped tons of industrial waste into a watershed that serves more than a quarter of the state's population. The Record claims that,

by Fords own estimates the amount of paint sludge the plant produced was 'thirty million gallons'. [The Record tested a chunk of the sludge and found that]...It contained lead at 100 times the states safety standard for soil. Antimony, a silvery-white metal that can cause heart and lung problems, was also 100 times the level considered safe. Arsenic was nearly nine times the safety standard. Chromium was double the safety level. Volatile organic compounds like xylenes and ethylbenzene were also present in hazardous concentrations...Long-term exposure to any of these chemicals is dangerous: Arsenic can cause lung cancer and skin disorders. Chromium increases the risk of lung cancer. Xylenes can wreak havoc on liver and kidneys and damage fetuses. Exposure to even low levels of lead can cause permanent damage, especially to a child's developing brain. [The article goes on to say that]...cleanup work in Ringwood has been temporarily halted. The sludge is just too contaminated to be accepted by the toxic landfill in Michigan...The Record tested a stream in the neighborhood and found it was tainted with benzene, a chemical known to cause leukemia and other blood disorders. Residents say paint sludge was dumped next to the stream's source. (Barry)

A DIRTY BUSINESS, BY THE NUMBERS

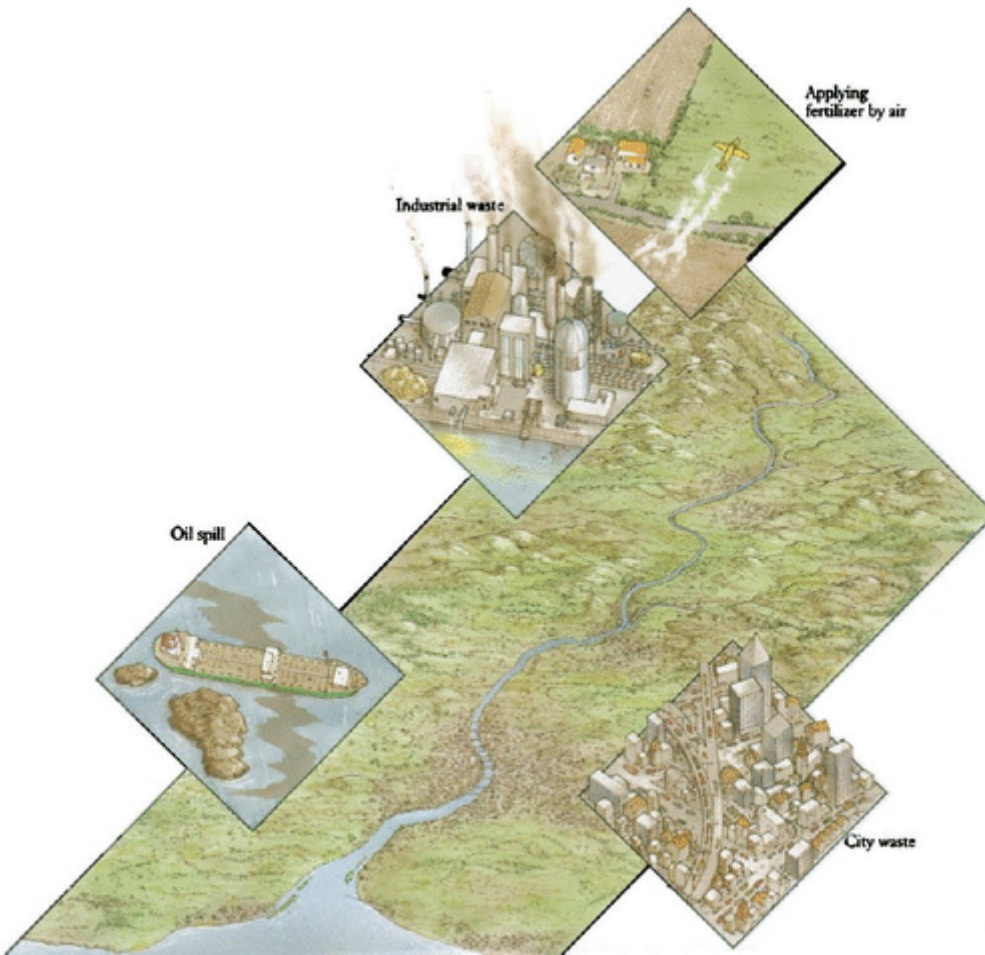


HOW THE PAPER INDUSTRY POLLUTES: All statistics are for the U.S. per year (except where noted), and they paint a grim picture. The industry is the third-largest source, after chemical and steel manufacturing, of greenhouse gases; these emissions are expected to increase 100 percent by 2020. It is the fourth-largest source of dioxin emissions. The amount of timberland destroyed to feed the paper industry is projected to increase globally by 50 percent in the next 35 years.

Source: Compiled by the Natural Resources Defense Council

RUSSELL COBB (ILLUSTRATION)

Fig. 8



As a river flows from its source to the ocean, there are many opportunities for its waters to become polluted. Farmland along the river valley may be treated with chemical fertilizers which, if not applied carefully, end up in the water. Cities are often located along the banks of a river and deal with wastes such as sewage by simply piping them into the water. Industries are also built along the banks, attracted by the supply of water for industrial processes and the ease of transporting goods. They often discharge chemicals that pollute the water. Even plain hot water discharged into the river from power plants lowers the water's oxygen content, killing the fish.

Fig. 9

Morgan, Sally, and Mike Allaby. "Chapter 7.2: Water Pollution." *The New Encyclopedia of Science: Ecology and Environment*. Dec. 1 2003: n.p. *SIRS Researcher*. Web. 13 Sep 2010.

Cancer rates in this area are many times the national average and many other forms of sickness abound.

The Ford plant produced some 6,000 gallons of sludge per day dumping most of it in the local area. Contamination of the areas drinking water is a real threat and there is fear that the poisons may work their way into the drinking water of 2½ million people.

If Ford can get away with this kind of polluting here in the United States where safety is supposed to be the number one priority what can car companies get away with in less developed countries of the world...it's a scary thought. (See figure 10).

Auto Fleets in Selected Developing Countries

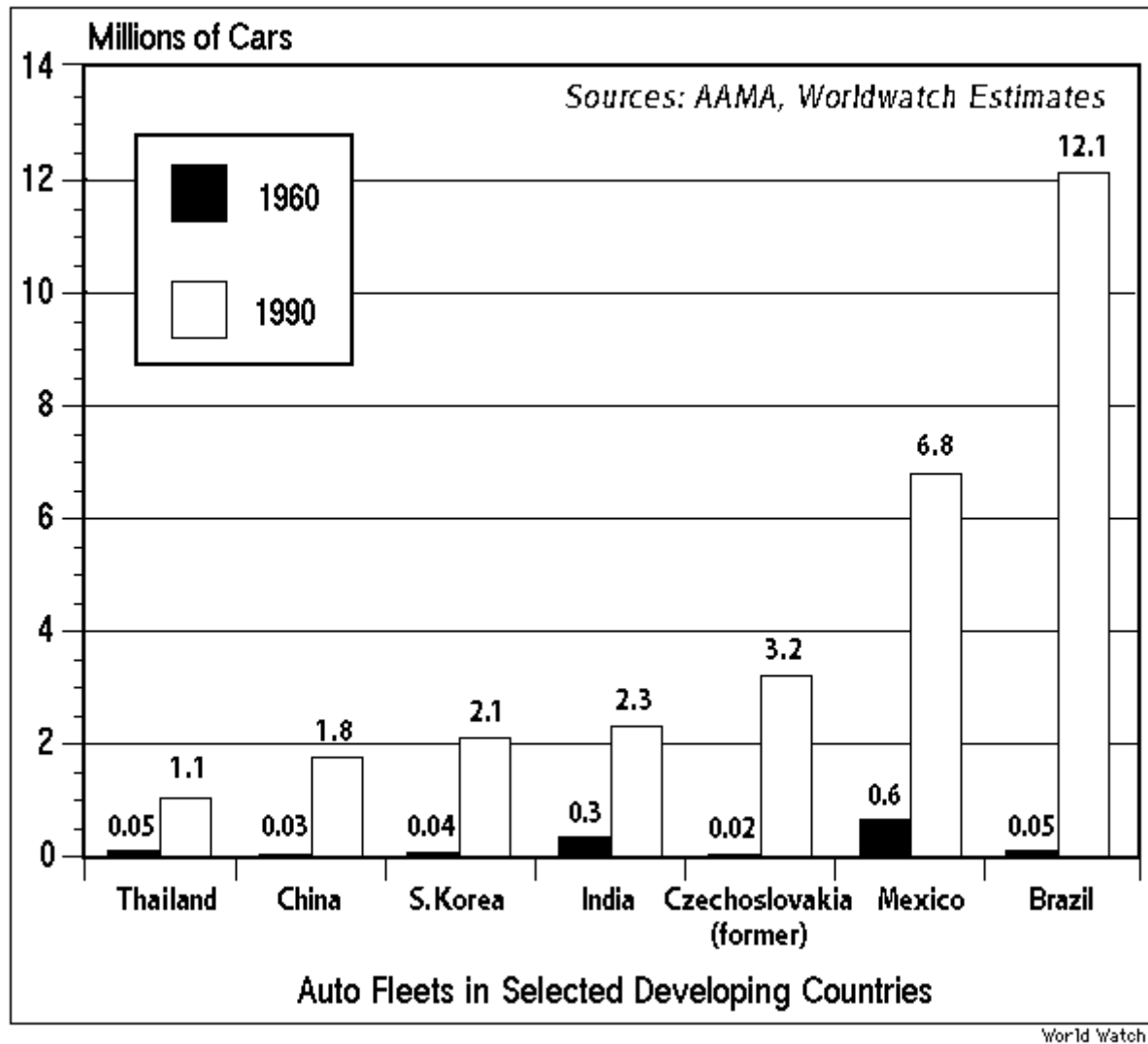


Fig. 10

Tunali, Odil. "A Billion Cars: The Road Ahead." *World Watch*. Jan./Feb. 1996: 24-35. *SIRS Researcher*. Web. 13 Sep 2010.

2 DEPLETION

Depletion of our ground water is a problem when you realize that the supply is finite. Ground water is naturally held in huge underground aquifers. These aquifers are basically underground rivers. Not much is known about the direction of flow, the amount contained or the quality of the water. This will soon change, however, because new remote sensing technologies are now being employed for aquifer mapping. The problem in coastal areas is inundation due to sea level rise. Development in dry areas promotes over pumping of aquifers which makes room for salt water inundation. Urbanization is another contributing factor to the problem of aquifer depletion in that things like driveways and parking lots prevent the natural run off that would otherwise replenish the aquifers.

Since not much is known about aquifers what is needed is knowledge. Remote sensing technology can now map the flow of ground water from the air. The U.S. Department of Energy, working with researchers, are seeing as deep as a thousand feet through solid ground, creating a three dimensional image of the flow. According to the Department of Energy,

To map the flow of groundwater, a helicopter flies a prepared grid pattern at about 200 feet above the ground, following the contours of the earth. Dangling about 100 feet below the helicopter is one of two types of remote sensors, both of which operate somewhat like sonar or radar, sending out signals and receiving back a sort of echo.

The "frequency-domain sensor" looks something like a torpedo or a super-sized sausage and sends out six different frequencies of electromagnetic waves. The "time-domain sensor," which looks like a giant spider web, uses a single, lower frequency signal that penetrates deeper into the ground.

Since different substances echo differently, researchers are able to distinguish between solids and liquids, rocks and water. The technology can roughly determine the quality of the water. More contaminated or salty water returns a stronger signal.

The aerial data are supplemented with more detailed, on-the-ground data collected with hand-held sensors. By analyzing the data using a geographic information system database,

researchers can produce a three-dimensional image of groundwater flow called a conductivity depth image. (Eyes in the Sky)

(See figure 11).

This technology is important and will prove to be even more important in the future. In this way intrusion of sea water into our coastal aquifers may be monitored. Sea level rise coupled with the urbanization of coastal areas is setting humanity up for a fall. According to Worldwatch institute,

...sea level rise is going to be an urban planner's nightmare. In many coastal cities, the problem is compounded by the fact that the land underneath them is sinking. Excessive groundwater pumping is the primary cause of this subsidence, but urban sprawl is a factor too, since buildings and pavement cause rainfall to run off instead of seeping back into the earth to recharge the groundwater. In addition to lowering the groundwater, this overpumping makes the cities vulnerable to a kind of underground flooding: as the freshwater is pumped out of coastal aquifers, saltwater tends to seep in. underground saltwater intrusion is a serious problem...continued sea level rise will tend to make the aquifers...even saltier...might very well turn too saline to use at all if the sea level rises by a meter or so....would force officials to spend billions of dollars on...desalination plants. (Hinrichsen)

Cape May County, New Jersey is an example of an area fighting this problem.

After providing drinking water to the summertime crowds for decades in the early 1960's, Cape May's wells went salty. They tried drilling new wells but these became salty almost immediately. Instead of continuing to drill in search of good water they installed a desalination plant at a cost of \$5 million. The plant can purify up to two million gallons a day. They drilled two new wells to feed the plant which forces water through plastic membranes and into the water main that supplies the cities customers. According to the Philadelphia Inquirer it works like this...

Helicopter with Remote Sensor



DOE is using remote sensors suspended from helicopters to map the flow of groundwater that may be affected by energy projects.

Remote Sensors--2 Types



The remote sensors can look like an airborne torpedo or a spider web, depending upon the type of technology employed.

Unknown. "Eyes in the Sky..." Techline. Aug. 28 2003: n.p. SIRS Government Reporter. Web. 01 Oct 2010.

Fig. 11

The Cape May plant works on a principle called reverse osmosis. It has two banks of 52 metal cylinders, each of which contains a tightly wrapped coil of membranes.

The membranes are semipermeable, meaning they let in water but not salt. With saltwater on one side and freshwater on the other, the freshwater would ordinarily flow through such a membrane to dilute the salty water and establish equilibrium—a process called osmosis.

The Cape May plant reverses that natural process, pumping the brackish water through the membranes at a pressure of 195 pounds per square inch. Only fresh water gets through...

Even during the winter when the population drops...the plant's operator...continues to run the system at nearly half of capacity...

But where to store the excess water?

Right back underground where it came from.

The plant generates about an extra 300,000 gallons a day during the off season, which is funneled down into well 4, one of several that were threatened by saltwater intrusion.

The wintertime infusions keep the salt at bay..., and the water stays there until summer, when up to 90 percent of it can be pumped out again...The other 10 percent is lost. (Avril)

(See figure 12).

River modification is another way that man is manipulating water resources. This will be discussed in chapter three.

3 RIVER MODIFICATION

The modification of rivers, while at first appearing to be good for humanity, comes with a slew of problems. Construction of large dams has been the norm for many years but so has environmental degradation. Dams were intended to provide electricity, prevent flooding and to store water for irrigation during the dry season. As it turns out they are also ruining natural fish habitat, providing habitat for vector borne disease and preventing sediment from flowing downstream. In some cases, dams have promoted the collapse of entire ecosystems.

Large dams are 15-20 meters high. Since the 1940's the number of large dams has grown from under a thousand to more than five thousand. (See figure 13). Recently, with environmental impacts becoming more apparent, large dam building has fallen out of favor. That's not to say that they are not being built, just that there may be less of them built in the future. The World Bank has pulled its funding of the Three Gorges Dam project in China because of negative environmental impact reports. The dam however was finished.

Dams may impact river species like wild salmon and steelhead. In the Pacific Northwest, wild salmon and steelhead populations have plummeted. Salmon live at sea but swim up rivers to spawn. With the introduction of dams the path to their native spawning grounds is cut off. The temperature of the water is also affected; storing the water in a reservoir raises the temperature making it too warm for fish to thrive. According to the High Country News,

...the famous salmon and steelhead runs that have used this stretch of river for tens of thousands of years on their way to and from the ocean continue to spiral toward extinction, and the dams have proven to be one engine of their destruction...[The article goes on to say that]...

Big Dams

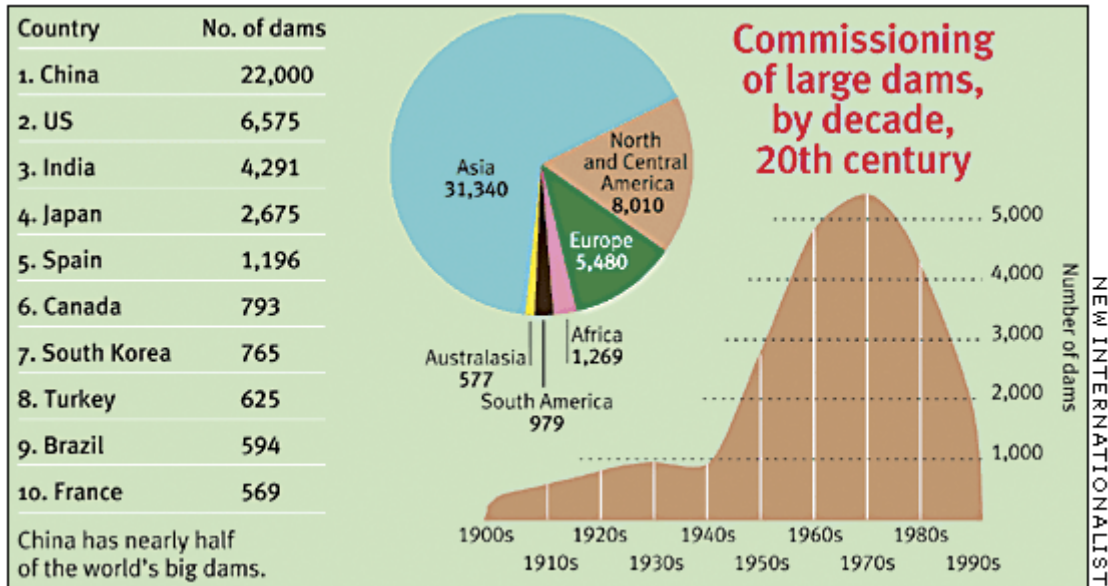


Fig. 13

Godrej, Dinyar. "Precious Fluid." *New Internationalist*. March 2003: 9-28. *SIRS Researcher*. Web. 13 Sep 2010.

Not only did the pressure generated by the dam's whirling turbines kill the (fish), but fish that were fortunate enough to get sent over the dam's spillway away from the turbines suffered from a form of the bends caused by the supersaturated gas created by the plunging waters. And without a current to push them through the reservoirs, the usually swift 14 day journey was extended by weeks, making fish more vulnerable to predators... (Larmer)

Another problem with dams is that the water is held in a reservoir. The reservoir holds water; water that was flowing is now still. Still or stagnant water is the ideal breeding ground for mosquitoes. Mosquitoes may serve as vectors or carriers of disease. One disease that they carry is malaria. (See figure 14). Malaria is a terrible disease that is responsible for more than two and a half million human deaths each year. (See figure 15). Millions of dollars are spent every year fighting this disease but really billions are needed. (See figure 16). Where big dams are built in some tropical areas the incidence of malaria goes up. Disease control should be planned for when these big dam projects are being considered or formulated.

No matter how well dams are built they always impact everything in a natural watershed. Rivers drain the land of water; they run through a drainage basins or watersheds, then through wetlands at the end of which they forms deltas from the sediment as they drain into the sea. The following is a selection of consequences provided by the World Watch Institute:

Some of the Earth's major arteries are now so constricted that their lifeblood no longer reaches its natural destination. The result is a massive failure of ecosystems and economies.

...The Nile, the Ganges, the Amu Dar'ya and Syr Dar'ya, the Huang He (or Yellow River), and the Colorado are now so dammed, diverted, or overtapped that for parts of the year, little or none of their fresh water reaches the sea...

Worldwide, dams collectively store on the order of 6,000 cubic kilometers of water—equal to 15percent of the earth's annual renewable water supply...

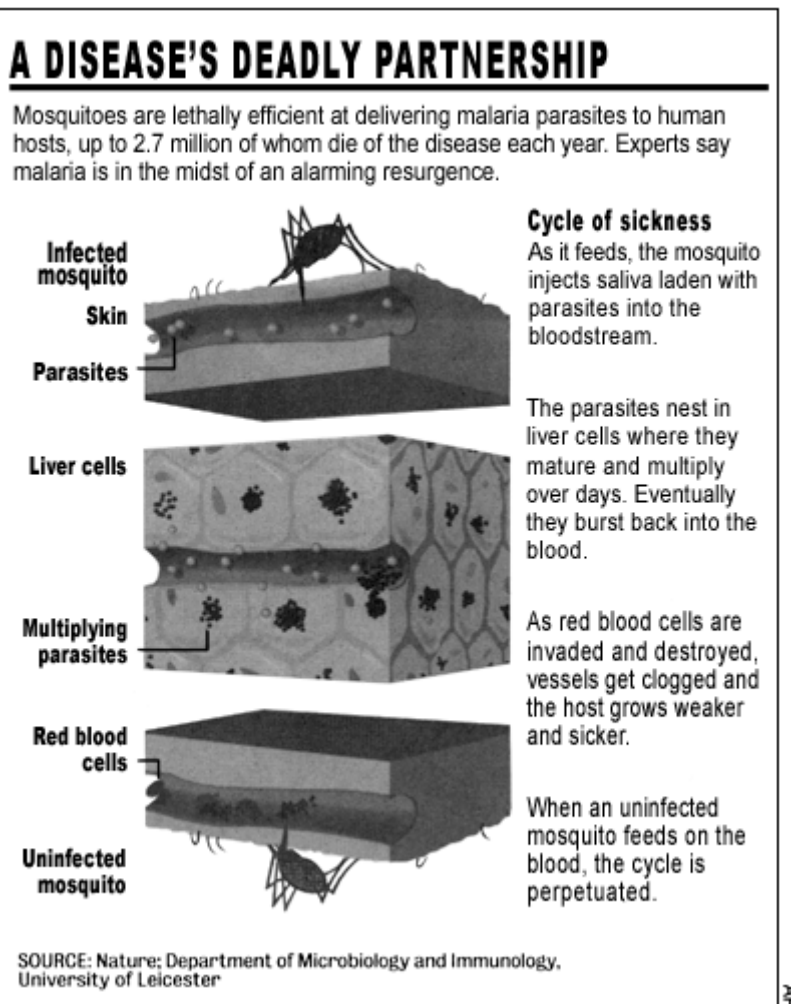
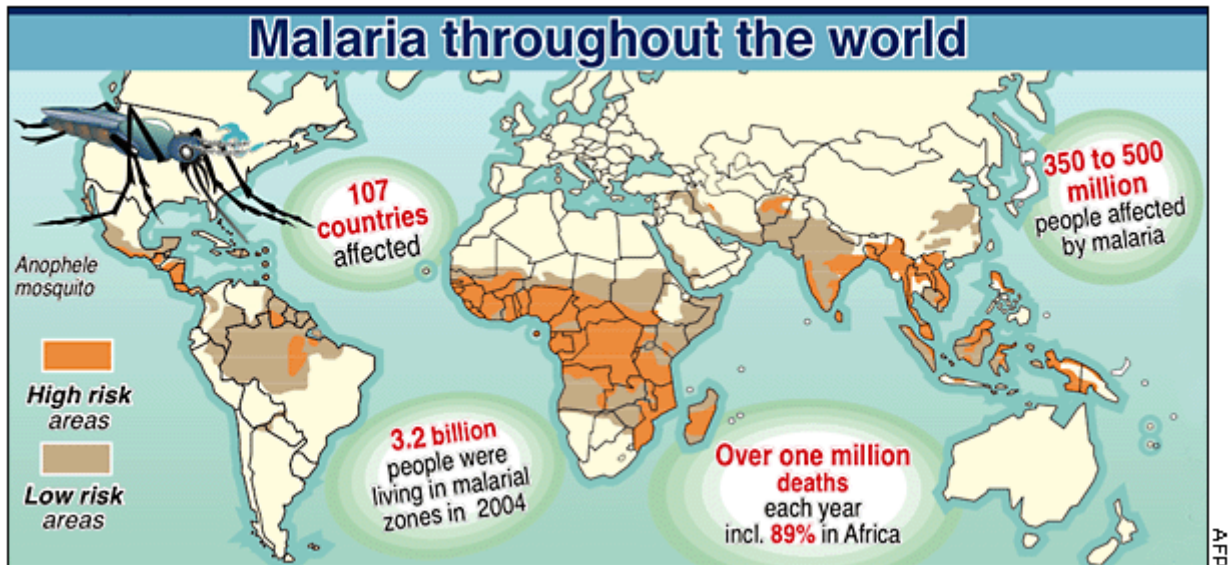


Fig. 14

Callahan, Rick. "Experts Seek Clues As Malaria Makes a Comeback." *Miami Herald* (Miami, FL). 30 Jun 2002: 24A. *SIRS Researcher*. Web. 13 Sep 2010.

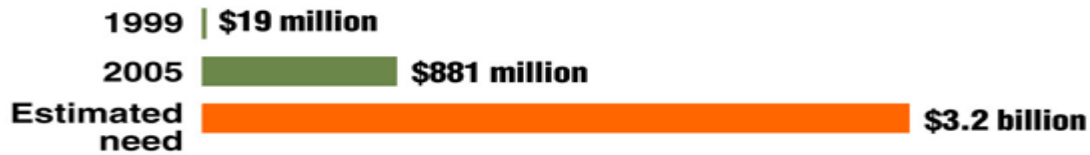


Unknown. "Cash the Main Barrier to Rolling Back Malaria, Say World Health Groups." *Agence France-Presse*. 03 May 2005: n.p. *SIRS Researcher*. Web. 01 Oct 2010.

Fig. 15

Funding for malaria control

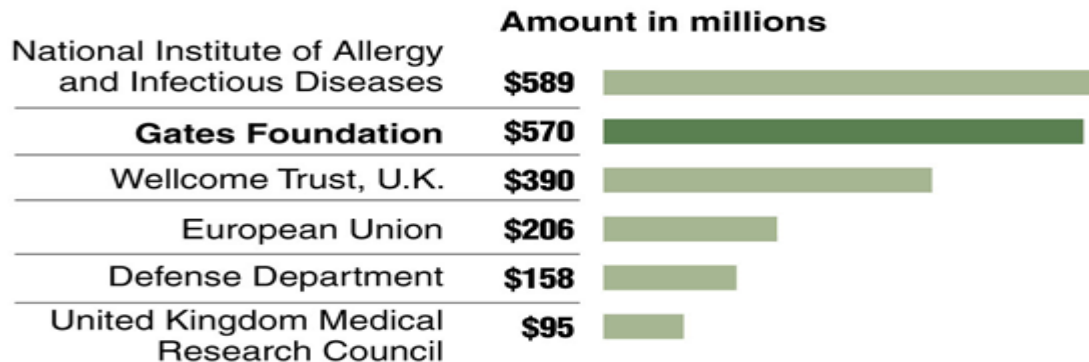
Worldwide spending for malaria control and treatment has increased dramatically but still falls short of targets.



Source: Trends in International Funding for Malaria Control, Roll Back Malaria Partnership; World Malaria Report 2005

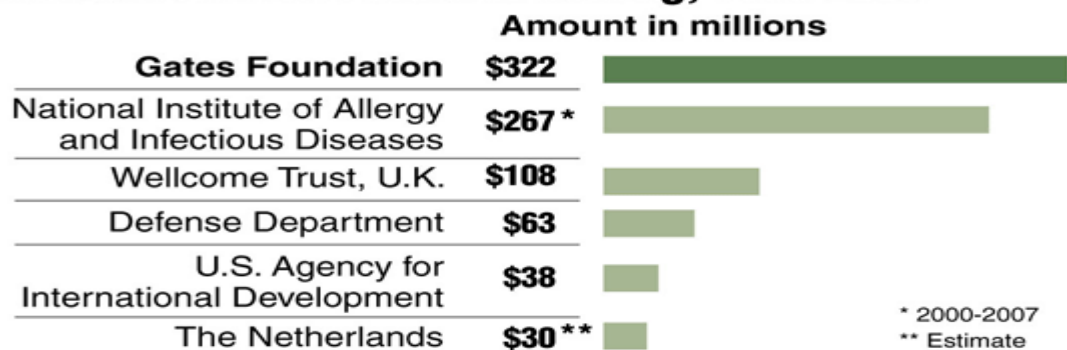
Research and development funding, 1999-2006

The Gates Foundation is second only to the U.S. government in total malaria research-and-development funding.



Source: Gates Foundation; NIAID; Wellcome Trust; European Union; Defense Department; Medical Research Council; Malaria R&D Alliance

Malaria vaccine research funding, 1999-2006



Source: Gates Foundation; NIAID; Wellcome Trust; Defense Department; USAID; Netherlands Ministry of Foreign Affairs; Malaria R&D Alliance
Graphic: The Seattle Times

* 2000-2007
** Estimate

© 2007 MCT

Fig. 16

...Rivers are central to the planet's ecology; turning them on and off at will damages other parts of the system. And because aquatic organisms cannot live long without water, large reductions in streamflow—even for short periods of time—can be damaging or deadly to them...

Only recently has much attention been given to the effects of these diminished flows on the river delta and estuary. The delta and upper Gulf of California comprise the largest and most critical desert wetland in the American Southwest, as well as one of the world's most diverse and productive sea ecosystems. Besides drying up the wetlands and causing a severe deterioration in water quality, a reduction in fresh water flow has also cut the flow of nutrients to the sea and reduced critical habitat for nursery grounds...

Perhaps the most threatening long-term consequence of the Nile's diminished flow is that of the delta, so essential to the country's economy, is slowly falling away into the sea. Most river deltas naturally subside from the weight of their own sediment, under natural conditions this is usually countered by deposition of silt brought in by the river...The delta stopped growing about a century ago...But since the completion of the High Dam, and the trapping of virtually all the silt in Lake Nassar, the delta has actually been in retreat. Borg-el-Borellos, a former delta village, is now 2 kilometers out to sea. (Postel)

(See figure 17).

Seabed Lies Exposed, Blowing Sand and Salt



The Aral Sea in Kazakhstan, central Asia, was once the world's fourth largest inland sea. Since 1960 it has shrunk 40 percent as the two rivers that fed it were tapped to irrigate cotton crops. The loss of the source water increased evaporation from the lake itself, which shrank some 27,000 sq km in area. This huge seabed lies exposed, blowing sand and salt throughout the region. The local climate is now too dry to grow cotton. (Victoria Ivleva/Impact Photos)

Morgan, Sally, and Mike Allaby. "Chapter 3.1: The Water Cycle." *The New Encyclopedia of Science: Ecology and Environment*. Dec. 1 2003: n.p. *SIRS Researcher*. Web. 01 Oct 2010.

Fig. 17

SUMMARY

A human induced water crisis is on the horizon. Man's manipulation of our fresh water supply has brought some unwanted changes in water availability and quality around the world.

Human populations are growing at an exponential pace with water use growing even faster. The green revolution is feeding all these people but irrigation is required along with pesticides and fertilizer. These additions are pollutants that through run-off and leaching get into our fresh water supplies and poison us and our environment. Lack of or old infrastructure allows us to be poisoned by sewage, while development poisons us through industry. There are many other ways that we are polluting our fresh water supplies, only a few are discussed here.

Aquifer depletion is one of the concerns. We need to keep them full in order to prevent subsidence and coastal inundation, not to mention diluting the pollutants that are leached into them. Using new blue technologies we are able to learn more about the water that resides deep under our feet.

Manipulating our rivers at first seemed like a good idea, building dams to prevent flooding in the rainy season and storage for use during the dry season. This has led to major problems within the hydrologic cycle, still or stored water breeds vector borne disease. Drainage basins are how rivers naturally filter their water. How are rivers supposed to clean and recycle themselves when they do not even reach these basins? Fish and everything else that was dependent on the river's flow has been thrown out of

sync with the natural balance. Nutrient rich sediment deposits have been intercepted and whole ecosystems are collapsing.

CONCLUSION

In conclusion I would ask people to really look at their water use and make any changes that would be beneficial to the hydrologic cycle. We should allot water for the Earth and animals to use, humans are not the only ones who need it to survive.

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